II.E. Bethel Valley Watershed and Melton Valley Watersheds

The X-10 site, now known at the Oak Ridge National Laboratory (ORNL) is about 10 miles southwest of the city center of Oak Ridge in Roane County, and encompasses approximately 26,580 acres. It is surrounded by heavily forested ridges that include Chestnut Ridge, Haw Ridge, and Copper Ridge (ChemRisk 1999a; TDOH 2000). The X-10 Site is situated within two watersheds – Bethel Valley and Melton Valley (ORNL et al. 1999). The main laboratory at X-10 is located along Bethel Valley Road, within Bethel Valley (ChemRisk 1999a; ORNL et al. 1999). The X-10 site also contains remote facilities and waste storage areas in Melton Valley (ORNL et al. 1999). White Oak Creek begins in Bethel Valley and flows south along the eastern border of the plant and travels through a gap in Haw Ridge before entering Melton Valley. From Melton Valley, White Oak Creek joins the Clinch River below Melton Hill Dam (ChemRisk 1999a). See Figure 1 for the location of White Oak Creek and the relationship between X-10, White Oak Dam, the Clinch River, and the Watts Bar Reservoir.

Operational History

Beginning in the early 1940s, radioactive material was used on the ORR for various processes, such as uranium enrichment, plutonium production, plutonium separation, and the development of separation processes for additional radionuclides (ChemRisk 1993b; Jacobs Engineering Group Inc. 1996). The X-10 site was built in 1943 as a "pilot plant" to demonstrate plutonium production and chemical separation. The government had intended to operate the facility for only one year. However, this initial time period was extended indefinitely as operations were continued and expanded at X-10 (ChemRisk 1999a; TDOH 2000). After World War II, the facility's focus was broadened to include non-weapons related activities, such as the physical and chemical separation of nuclear products, the creation and assessment of nuclear reactors, and the production of a range of radionuclides for global use in the medicinal, industrial, and research disciplines (ChemRisk 1993b). In the 1950s and 1960s, the X-10 site became a worldwide research center to study nuclear energy and to investigate the physical and life sciences that are related to nuclear energy. From 1958 to 1987, the Oak Ridge Research Reactor operated to support various scientific experiments at X-10. For a long period of time, this reactor was the main radionuclide supplier to the "free world" for medical, research, and industrial purposes (Johnson & Schaffer 1992, Stapleton 1992, and Thompson 1963 as cited in ChemRisk 1993b).

Geology/Hydrogeology

The entire X-10 site was built on the Chickamauga Group (see Figure B-1). This aquifer formation is a flow limiting strata that has a relatively low hydraulic conductivity. This formation is subject to upper-level fracturing, but these cracks and fissures are typically only a few centimeters wide and serve more as groundwater storage as opposed to facilitating the spatial movement of groundwater (MMES 1985). Haw Ridge separates Bethel Valley from Melton Valley. This ridge was formed partially from thrust faulting by compressive tectonic forces millions of years ago. It is also a result of differential weathering. Underlying Haw Ridge is the Rome Formation. This siliciclastic formation is composed primarily of siltstone, sandstone and shale (USGS 2004). The Rome formation is more resistant to weathering than the Chickamauga Group, which underlies the Bethel Valley to the north, and the Conasauga Group, which underlies Melton Valley to the south.

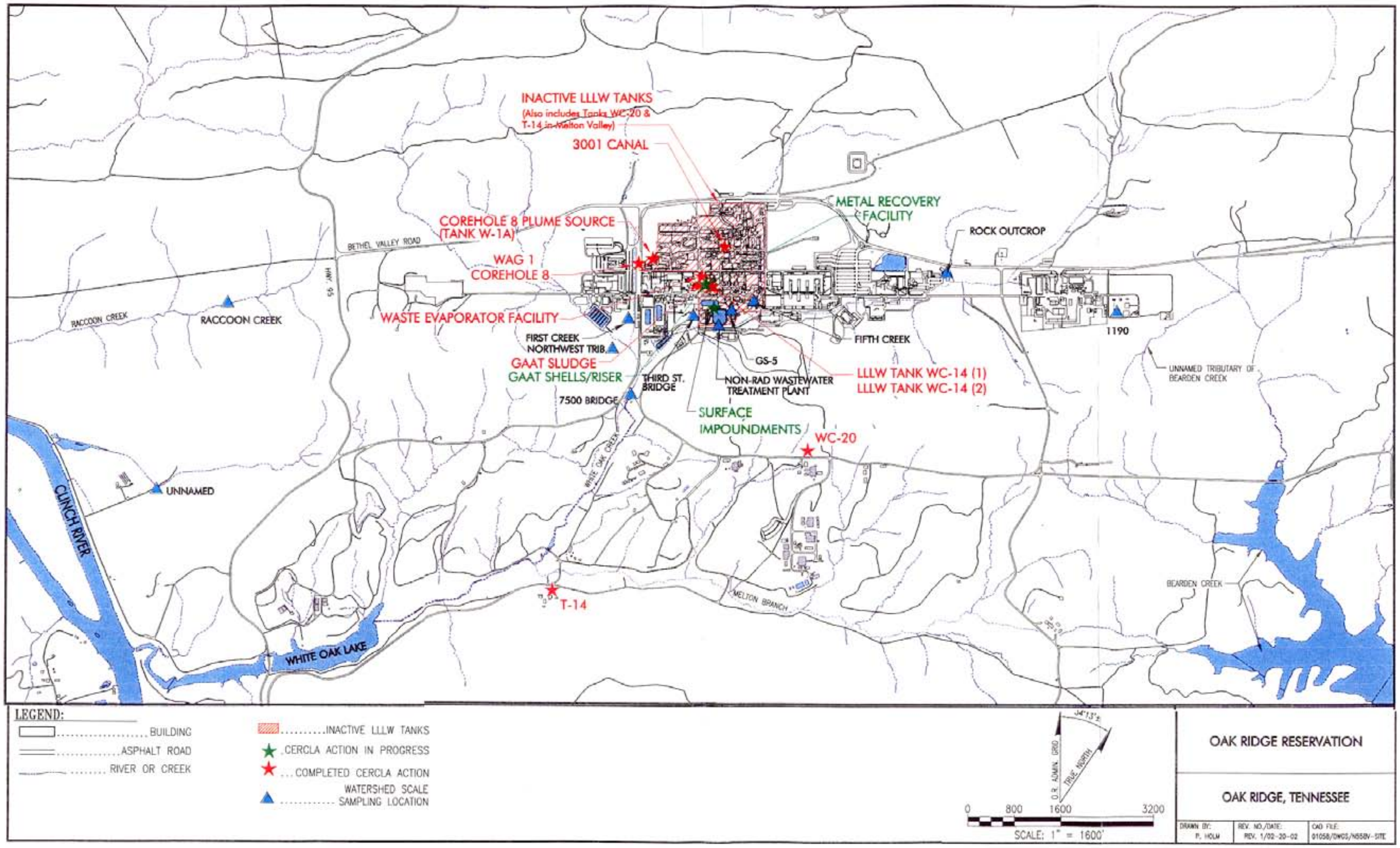

Figure 5: Major Remedial Activities in Bethel Valley

Groundwater in the ORR area generally occurs in the unconsolidated zone. Depth to the water table, depending on seasonal variability, in the Bethel Valley ranges from 1 to 35 feet and from 1 to 67 feet in Melton Valley. Groundwater flow paths most often mirror the surface topography with diffuse discharge to surface waters or as discharge via springs and seeps (Figure 7). In the Bethel Valley, there is a hydrologic divide separating surface water flow in the western third of the watershed. West of the divide, surface water and groundwater flow west to Raccoon Creek (Figure 6) and eventually into the Clinch River. East of the divide, waters flow east to White Oak Creek. Groundwater flow generally follows these topographic trends and flow paths to surface water are relatively short (ORNL 2004).

White Oak Creek flows through a gap in Haw Ridge from Bethel Valley to Melton Valley. Soils in the Melton Valley area, overlying the Conasauga Shale, have a low primary porosity and therefore, have a low storage capacity. The common concept of contaminated groundwater plume migration is not appropriate in this area because of the shallow active zone and the interaction with surface water. The water that infiltrates into the upper weathered zone eventually discharges into streams via the "bathtub effect" – where water collects in a low area, or trench, causing an overflow at the down gradient end (MMES 1985). This overflow occurs as springs or seeps from which water flows downhill to creeks and streams (Figure 7).

Contamination in Bethel Valley and Melton Valley

The major operations at X-10 take place within the Bethel Valley Watershed. The main plant, key research facilities, primary administrative offices, as well as various forms of waste sites, are situated in Bethel Valley. Over the past 60 years, X-10 releases have contaminated the Bethel Valley Watershed. Mobile contaminants primarily leave the Bethel Valley Watershed via White Oak Creek. These contaminants travel from the Bethel Valley Watershed to the Melton Valley Watershed, where further contaminants enter White Oak Creek. Then, the contaminants that have been discharged to White Oak Creek are released over White Oak Dam and into the Clinch River (U.S. DOE 2001d).

Bethel Valley Contamination

For the purpose of environmental investigation and remediation, the Bethel Valley area was subdivided into four regions. The regions are; Raccoon Creek, West Bethel Valley, Central Bethel Valley, and East Bethel Valley (Figure 6). The Raccoon Creek area lies on the western most portion of the valley west of Highway 95. West Bethel Valley lies east of Highway 95 and west of the ORNL main plant area. While the Raccoon Creek area does not have any known contaminant source areas, West Bethel Valley contains a burial ground (SWSA 3) and adjacent landfills, which have resulted in soil and groundwater contamination in both West Bethel Valley as well as Raccoon Creek. Radiological wastes were stored in SWSA 3 from 1946 to 1951 from DOE facilities all over the country. The SWSA 3 and the adjacent landfills cover approximately 18 acres in Bethel Valley. Over the years, seasonal surface water infiltration and heavy rain events have resulted in contaminant leaching from SWSA 3 and the adjacent landfills. Subsurface contaminant movement was short, flowing to Raccoon Creek to the southwest, and northeast to the Northwest Tributary (SAIC 2004).

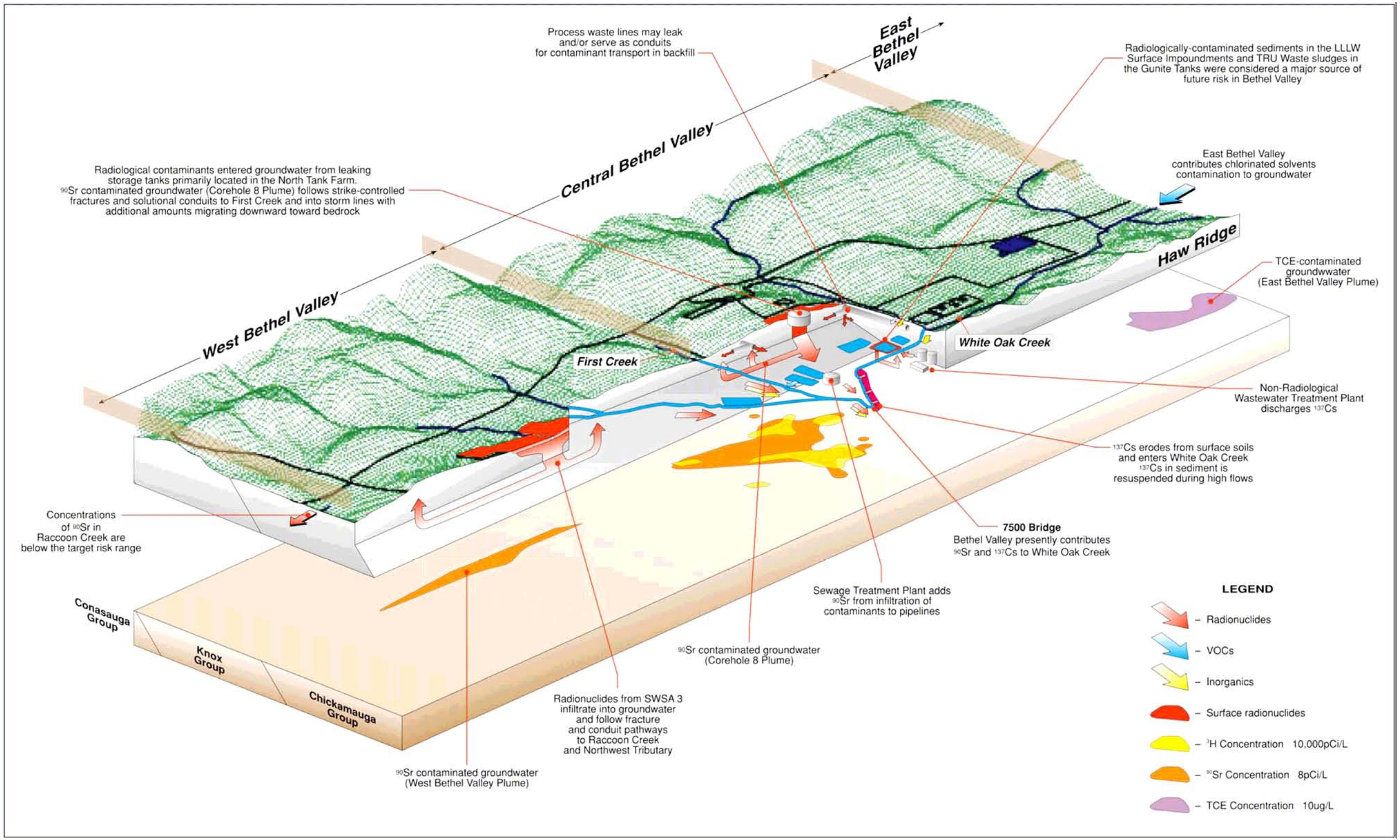

Figure 6: Conceptual Model of Groundwater Flow and Contaminant Transport in Bethel Valley

While the Raccoon Creek and the West Bethel Valley areas have relatively small defined contaminant release areas, the Central and East Bethel Valley areas have extensive soil and groundwater contamination. The Central Bethel Valley contains the main ORNL plant site and has over 150 sites that have been identified for environmental restoration (SAIC 2004). The leading areas of concern in terms of groundwater contamination in the Central Bethel Valley are the Corehole 8 plume and in some building sumps which have tested positive for mercury contamination (Figure 5). However, the only groundwater plume that is regularly monitored on a watershed scale is the Corehole 8 plume (SAIC 2004).

The Corehole 8 Plume, which was identified at X-10 in 1991, is a plume of groundwater that is contaminated with Sr 90 (SAIC 2002, U.S. EPA 2002a). In 1994, a removal site evaluation revealed that contaminated groundwater was leaching into X-10's storm drain system and was being released into First Creek. First Creek is a stream that feeds into White Oak Creek and ultimately flows into the Clinch River. Additional evaluation indicated that the contaminated groundwater was seeping into the storm drain system via three catch basins on the western portion of X-10 (SAIC 2002). In November 1994, an action memorandum was approved; by March 1995, a groundwater collection and transmission system was being used at the Corehole 8 Plume to prevent groundwater infiltration (SAIC 2002, U.S. EPA 2002a). Through this system, groundwater is treated by X-10's Process Waste Treatment Plant (PWTP) and then released through a National Pollutant Discharge Elimination System (NPDES) outfall.

In August 1995, DOE prepared a removal action report that required monthly monitoring of the storm drain outfall close to the joining of First Creek and the Northwest Tributary (Figure 5). In addition, based on suggestions from the 1997 remediation effectiveness report (RER), monthly composite samples are taken at this area, as well as at the Corehole 8 sump (SAIC 2002). Surface water monitoring in October 1997 revealed elevated levels of Sr 90 and uranium 233 (U 233) in First Creek. In December 1997, further investigation indicated that this contamination was entering the area through two unlined storm drain manholes. As a result, in March 1998, DOE established another interceptor trench that linked to one of the plume's collection sumps. An addendum to the original action memorandum was approved in September 1999. This addendum, which was intended to increase the effectiveness of the initial remedial action, endorsed more groundwater extraction and treatment activities at the Corehole 8 Plume (SAIC 2002, SAIC 2004). The source of the Corehole 8 plume is the W-1A tank in the North Tank Farm. This tank was commissioned in 1951 to receive LLLW from Buildings 3019, 3019B, and 2026, but use of the tank was discontinued in 1986 because of leaks in the transfer lines. Grab samples of soil around the W-1A tank revealed extremely high levels of transuranic waste (TRU). The tank is still in place because it was determined that removal of the tanks would result in a high dose rate to the workers (SAIC 2004).

Melton Valley Contamination

In the late 1950's, scientists at ORNL began experimenting with injecting low-level radioactive waste mixed with a Portland cement into induced fractures of the underlying bedrock. The geologic formation involved was a low-permeability formation of the Conasauga Group called the Pumpkin Valley Shale. Two experimental sites were developed for testing of this disposal method. The first was Hydrofracture-1 (HF-1) and the other was HF-2. At each site twenty-four observation and monitoring wells were installed. Various experiments revealed that the Pumpkin

Valley Formation could effectively and safely contain the contaminated grout. Continued experimental and, later, successful operational waste disposal was performed at two other injection sites (Old Hydrofracture Facility and New Hydrofracture Facitily – OHF and NHF) until operations were halted in 1982. The Underground Injection Control regulations promulgated by the USEPA effectively eliminated hydrofracture waste injections at ORNL (SAIC 1997, ORNL 2000). In 2000, Bechtel Jacobs Company LLC (BJC) contracted Tetra Tech NUS, Inc and their sub-contractor Texas World Operations, Inc. to perform the plugging and abandonment (P&A) of 111 wells in Melton Valley (Whiteside et al. 2002). As of FY 2002, demolition and deconstruction activities at OHF were completed and 110 of 111 hydrofracture wells have been plugged and abandoned (P&A) exceeding ALARA principles on the project (SAIC 2004, Whiteside et al. 2002). Contaminated grout is expected to remain in the induced hydrofractures in the Pumpkin Valley Shale or within boreholes or wells penetrated by grout. There is no known contribution to surface water contamination from hydrofracture waste (SAIC 1997).

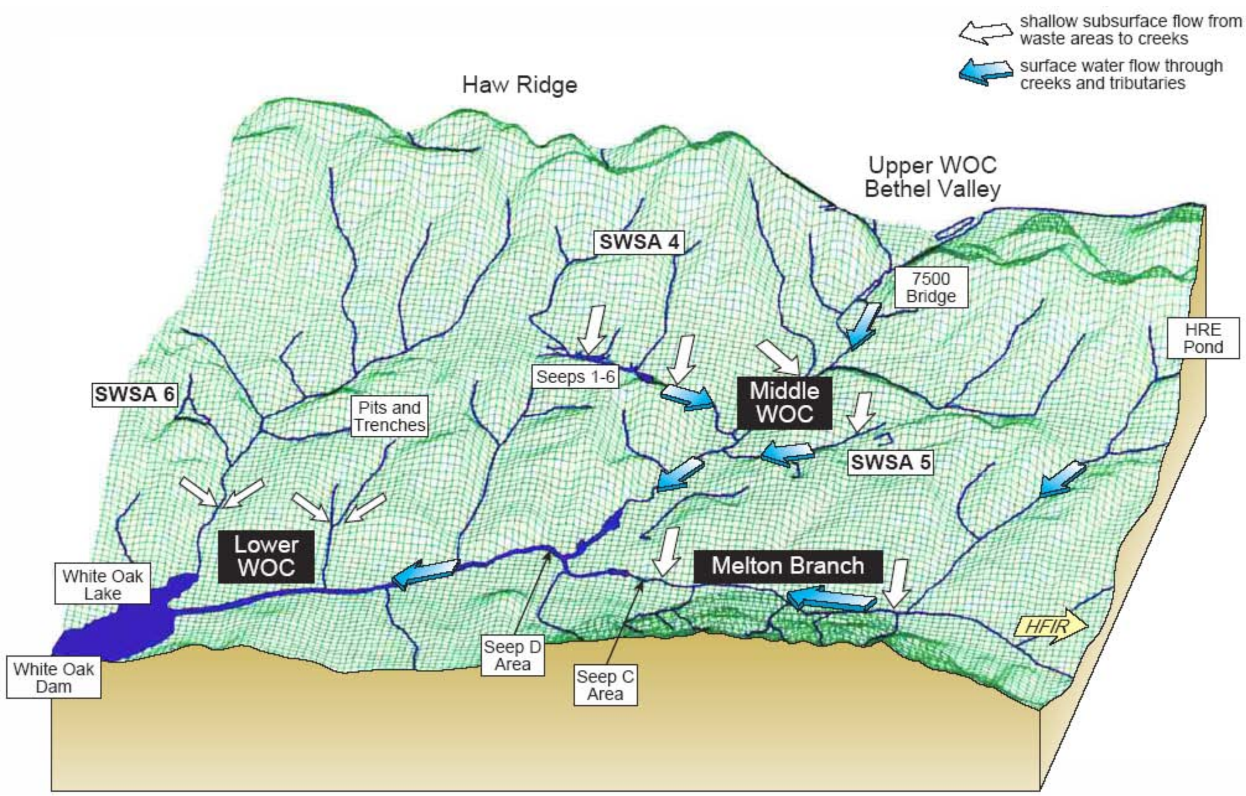

Figure 7: Surface Water and Shallow Groundwater Flow in Melton Valley

Melton Valley served as the U. S. Atomic Energy Commission's (AEC's) Southern Regional Burial Ground for wastes for ORNL and over 50 other facilities. X-10 disposed of its radioactive wastes (liquid and solid) in Melton Valley, and also operated its experimental facilities within this watershed (U.S. DOE 2002a, 2002b). The major burial grounds are SWSA's 4, 5, and 6. Wastes were buried predominantly in unlined trenches and auger holes. Consequently, discharges from Melton Valley's waste areas have produced secondary contamination sources that include sediment, groundwater, and soil contamination. Furthermore, contaminants that are discharged from Melton Valley travel off the reservation through surface water and flow into the

Clinch River (SAIC 2002, USGS 1988). As a result, the greatest impact to off-site receptors is from strontium 90 (^{90}Sr), tritium (^{3}H), and cesium 137 (^{137}Cs) contaminated surface water flowing across the White Oak Dam (WOD). The three primary release areas in Melton Valley are the SWSA 4 seep areas, and SWSA 5 Seeps C and D (SAIC 2004).

The SWSA 4 seeps area is located at the X-10 site (U.S. DOE 2001e). Data collected at the ORR suggest that releases from SWSA 4 have contributed to approximately 25% of the overall ^{90}Sr that is discharged over White Oak Dam (SAIC 2002). SWSA 4 consists of 23 acres that were used between 1951 and 1974 for industrial and radioactive waste burial (SAIC 2002). DOE's investigation revealed that two seeps produced about 70% of the overall ^{90}Sr that was discharged from SWSA 4 (SAIC 2002; U.S. DOE 2001e). Because contaminants from these waste trenches migrated into White Oak Creek, grouting techniques were used to reduce the releases of ^{90}Sr from these trenches; these activities were completed in October 1996. Surface water monitoring revealed that, as of 2001, these efforts had resulted in the ^{90}Sr releases being reduced by about 33% (SAIC 2002).

In 1994, DOE conducted an assessment and remedial activities at SWSA 5 Seeps C and D. The assessment found that ^{90}Sr was discharged from the X-10 site, and that Seeps C and D were major sources of off-site releases. Seeps C and D are located in the southern portion of WAG 5, which consists of a burial site used for radioactive waste disposal between 1951 and 1959 (SAIC 2002; U.S. DOE 2001f). Since ^{90}Sr could potentially constitute a significant threat to off-site populations, one of DOE's main goals was to minimize these discharges from SWSA 5 into the White Oak Creek system (SAIC 2002; U.S. DOE 2001f; U.S. EPA 2002a). The objective of these remedial activities was to reduce the quantity of ^{90}Sr in collected groundwater by at least 90% (SAIC 2002; U.S. DOE 2001f).

DOE's investigation in 1994 showed that Seep C was a major source of ^{90}Sr releases to White Oak Creek (SAIC 2002). Of the strontium detected at White Oak Dam between 1993 and 1994, 20% to 30% was released from Seep C. In March 1994, an action memorandum was accepted, and by November 1994, a "French" drain had been installed at Seep C. The French drain collects the groundwater and directs it to a unit for treatment; this treatment unit consists of drums filled with minerals that filter the ^{90}Sr. Once the groundwater is treated, it is released into Melton Branch. Thus, the primary goal of these remediation activities is to lower the amount of ^{90}Sr that is released to Melton Branch, and therefore, to off-site locations (SAIC 2002; U.S. DOE 2001f). According to samples taken in 2000 and 2001, the treatment unit has prevented over 99% of the ^{90}Sr at Seep C from entering Melton Branch (SAIC 2002). The amount of ^{90}Sr is greater downstream from Seep C than upstream, which suggests that a portion of the ^{90}Sr from WAG 5 bypasses the treatment unit (SAIC 2002; U.S. DOE 2001f). Currently, there are bimonthly sampling and weekly inspections of the treatment unit at Seep C (SAIC 2002).

Seep D was also a major source of ^{90}Sr to the White Oak Creek watershed (SAIC 2002). Of the ^{90}Sr detected at White Oak Dam between 1993 and 1994, 7% was released from Seep D. An action memorandum was passed in July 1994, and a groundwater treatment unit was installed and functioning at Seep D by November 1994. Once the groundwater has been treated, it is released to Melton Branch (SAIC 2002; U.S. DOE 2001f). Data collected in 2000 and 2001 showed that this treatment unit has prevented over 99% of the ^{90}Sr at Seep D from entering Melton Branch (SAIC 2002). However, the amount of ^{90}Sr is greater downstream at Seep D than upstream. This suggests that small quantities of ^{90}Sr going into Melton Branch did not originate from the Seep D pumping location (SAIC 2002; U.S. DOE 2001f). Daily inspections are conducted at Seep D and monthly sampling is performed on the treatment unit, as well as upstream and downstream of Melton Branch (SAIC 2002).

All of the waste areas in the Melton valley are in the aquitard formations of the Conasauga Group, where permeability, and consequently, groundwater migration, is limited (USGS 1988). As is the case in much of the ORR, groundwater flow is very shallow is closely coupled with surface water. Greater than 95% of the rainwater that infiltrates the soil ends up as surface water in White Oak Creek and eventually in to the Clinch River (ORNL 1982, SAIC 2004). As a result, most of the monitoring that is performed in Melton Valley concerns surface water with emphasis on the WOD. Surface water contamination in this area is addressed in the White Oak Creek Public Health Assessment.

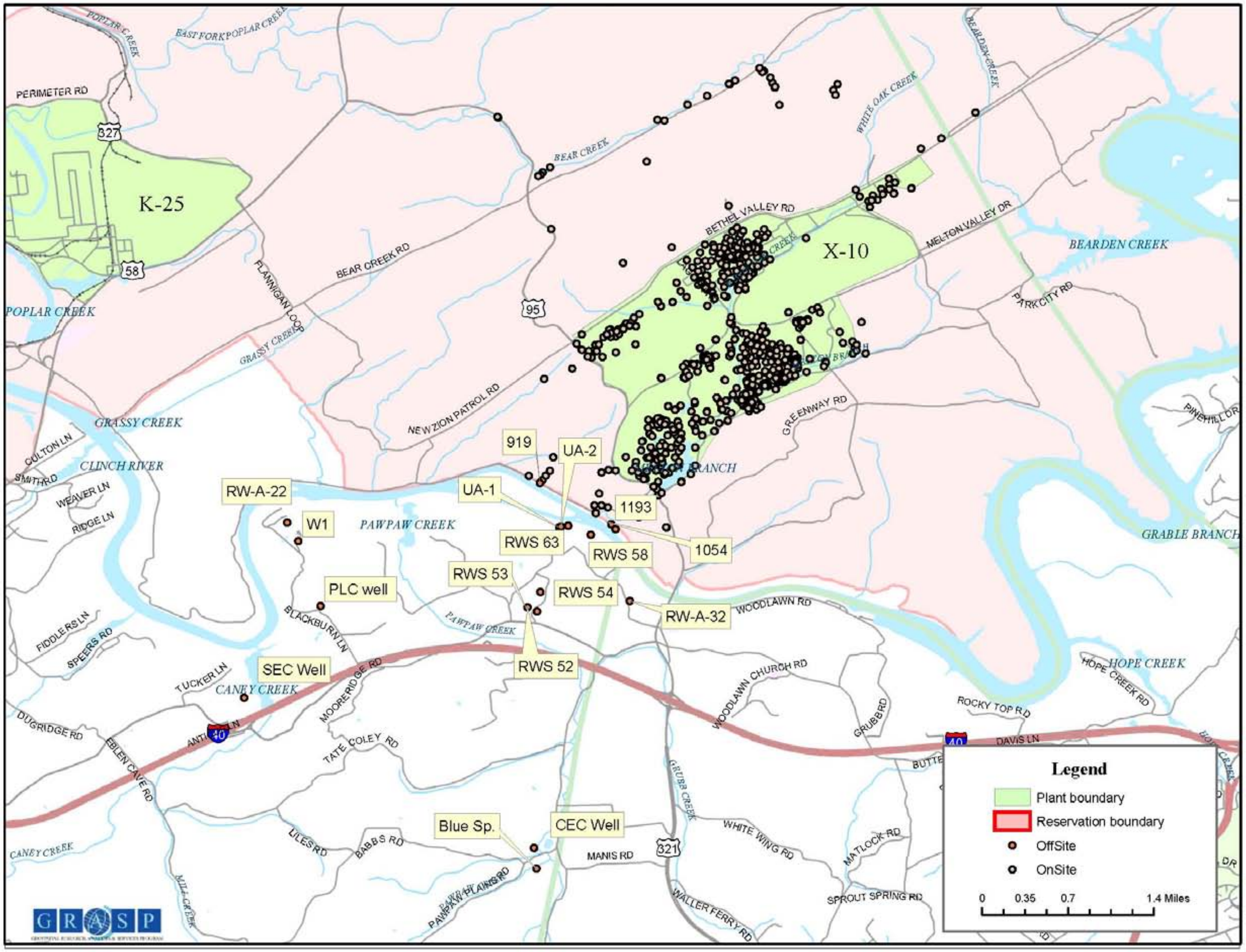

Figure 8: Off-Site Groundwater Sampling Locations Near ORNL

Off-Site Groundwater Monitoring Data

Seeps and Springs

Thallium was detected in one of seven samples from seeps and springs off-site near ORNL. The detected sample was taken from the SEC Well on March 4, 1996 and revealed a concentration of 2.4 ppb, which is slightly above the 2 ppb MCL for thallium. Thallium was not detected in a sample collected from the same location six months earlier. Subsequent sampling at that location has not been conducted.

Monitoring Wells

Table 2: Contaminants Detected Above Comparison Values in Monitoring Wells in the Bethel Valley and Melton Valley Watersheds

Substance	*Detects / Samples*	*Samples Detected Above CVs*	*CV (ppb)*	*CV Source*	*Max Conc. (ppb)*	*Max Location*	*Max Conc. Date*
Boron	8 / 9	8	100	EMEG	243	1193	5/13/1994
Iron	6 / 11	1	10950	RBC for tap water	16200	PLC Well	9/7/1995
Thallium	2 / 11	2	2	MCL	2.4	PLC Well	3/4/1996

Boron was only detected in one well – well #1193. Boron was not detected in the most recent sample from this well, which occurred on April 3, 1996. Iron was only detected above the 10950 ppb CV in one sample. This sample was taken from the PLC Well in September of 1995. A subsequent sample, six months later, from the same well yielded a concentration of 2550 ppb – well below the CV. Both samples with elevated thallium concentrations were taken from the PLC Well. No subsequent sampling has taken place for thallium at the PLC Well.

Residential Wells

There have been no contaminants detected above comparison values in residential wells near the ORNL.

ATSDR Conclusion for Bethel Valley and Melton Valley Watersheds

Groundwater in Bethel Valley and Melton Valley has short flow-paths to surface water, namely, First Creek, Raccoon Creek, the Northwest Tributary and White Oak Creek. Contaminated groundwater has not migrated to the ORR boundary. Remediation of groundwater in Bethel Valley is ongoing as it is in Melton Valley. Contaminant concentrations in general are either decreasing or are steady. There is no site-related groundwater contamination beyond the ORR boundaries from operations in Bethel or Melton Valleys. Thallium has been detected sporadically in seeps/springs and monitoring wells near ORNL. While subsequent sampling has not been conducted at the specific locations (SEC Well and PLC Well), concurrent sampling from adjacent locations have not been able to detect thallium. Iron and boron were not detected in subsequent sampling events. No contamination has been detected in residential wells near

ORNL. For these reasons, ATSDR concludes that there is no public (community) exposure to groundwater contamination emanating from the ORNL.

II.F. Bear Creek and Upper East Fork Poplar Creek Watersheds

The Bear Creek watershed and the Upper East Fork Poplar Creek (UEFPC) watershed comprise a large portion of Bear Creek Valley on the ORR. Bear Creek Valley is bordered by Chestnut Ridge and Pine Ridge. The 825-acre Y-12 plant, now called the Y-12 National Security Complex, is located in Bear Creek Valley and lies predominantly in the UEFPC watershed.

Operational History

From 1944 to 1947, the Y-12 Complex was used to electromagnetically enrich uranium. In 1952, the facility was converted to enrich lithium-6 using a column-exchange process and to fabricate components for thermo-nuclear weapons using high-precision machining and other specialized processes. In 1992, after the Cold War ended, Y-12's mission was curtailed, and the plant is currently used for weapons disassembly and weapon renovation operations. The National Nuclear Security Administration currently uses the Y-12 National Security Complex as the primary storage site for highly enriched uranium. While operational levels have increased since 1992, the total operations have not approached the levels experienced before the 1990's.

Geology/Hydrogeology

The Y-12 Complex is located in the eastern end of Bear Creek Valley. It is bordered on the south by Chestnut Ridge and on the north by Bear Creek Road and Pine Ridge (ChemRisk 1999). The main Y-12 production area is about 0.6 miles wide and 3.2 miles long; the area contains roughly 240 principal buildings, of which about 18 were directly involved with processing and/or storage of uranium compounds (Patton 1963; UCC-ND 1983 as cited in ChemRisk 1999). The Y-12 Complex is located within the corporate limits of the city of Oak Ridge, about 2 miles south of downtown (ChemRisk 1999). It is less than a half mile from the Scarboro community, but Pine Ridge (which rises to about 300 feet above the valley floor) separates the Y-12 Complex from the main residential areas of Oak Ridge (TDOH 2000). Figure 9 illustrates how groundwater flows along strike in Pine Ridge and Chestnut Ridge. Indeed, the southward sloping orientation of the bed planes beneath Pine Ridge prevents groundwater from flowing north toward Scarboro.